Testing of Screening Effectiveness of CATV Cables & TV Receiver Leads

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Cables for cabled distribution systems and satellite service (CATV cables) are standardized in the *IEC 61196* series. TV receiver leads are described in the *IEC 60966* series. Besides electrical and mechanical characteristics, these standards specify the screening classes.

For trouble-free TV reception and against unwanted radiation from cabled distribution systems, at least the screening class A is required. Regarding possible 4G/LTE problems, the screening class A+ is recommended (see **Table 1**).

Table 1. Screening Classes for CATV Cables According to *IEC 61196/EN 50117* as well as for TV Receiver Leads According to *IEC 60966*.

Frequency range [MHz]	Limit value		Test procedure
Transfer impedance	Class A+	Class A	**Triaxial procedure**
5 to 30	≤ 2,5 mΩ/m	≤ 5 mΩ/m	IEC 62153-4-3 /-4-7 [1])
Screening attenuation			**Triaxial procedure**
30 to 1 000	≥ 95	≥ 85	IEC 62153-4-4 IEC 62153-4-7 [1])
1 000 to 2 000	≥ 85	≥ 75	
2 000 to 3 000	≥ 75	≥ 65	
1) For TV receiver leads IEC 62153-4-7 applies			

As a test method of the shielding effectiveness, the triaxial test procedure applies to *IEC 62153-4-n*. These measurement methods are currently being revised by *IEC TC 46/WG5*. The changes to these standards as well as improvements to the triaxial procedure are described below.

New Standards for Transfer Impedance & Screening Attenuation

Changes of IEC 62153-4-3, transfer impedance. The transfer impedance is in principle the resistance of the screen over the frequency, and it is length dependent.

Previously required adaptation of the characteristic impedance of the DUT to the output impedance of the generator can now be omitted. Impedance matching is no longer required. To measure the transfer impedance, three methods are now possible (see **Figure 1**, **Figure 2** and **Figure 3**).

Method B (seen in **Figure 2**) is recommended, since transfer impedance and screening attenuation can be measured with the same test setup.

Changes of IEC 62153-4-4, screening attenuation. The screening attenuation a_S is the measure of the effectiveness of a cable screen. It is the logarithmic ratio of the feeding power P_1 to the maximum radiated power P_2.

$$a_S = 10 \cdot \log\left|P_1 / P_2\right| = 20 \cdot \log\left|U_1 / U_2\right| \qquad (1)$$

Details are described in *IEC 62153-4-4*.

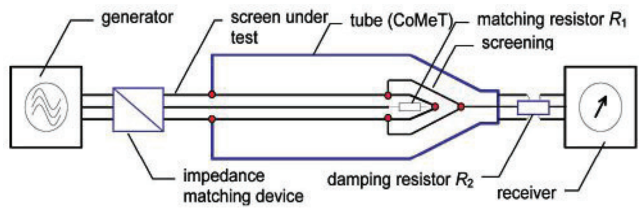

Fig. 1 — Test method A – Matched-matched-short with damping resistor R2.

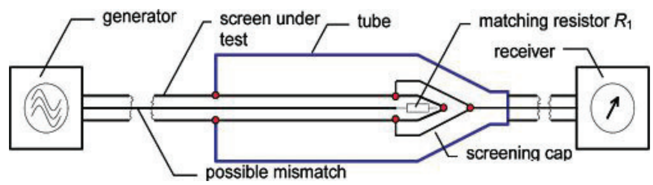

Fig. 2 — Test method B – Mismatched-matched-short.

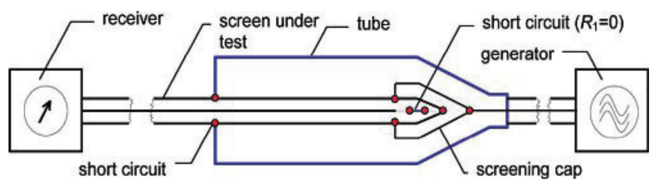

Fig. 3— Test method C – Mismatched-short-short.

So far, the shielding effectiveness was measured using a matching device. The sample was terminated by its characteristic impedance. The generator has been adapted to an impedance converter to the impedance of the DUT.

Edition 2 of *IEC 62153-4-4* allows now the test with matching conditions as well as with mismatch between generator and DUT. An impedance matching device is no longer required. The test set-up of *IEC 62153-4-4* Edition 2 is given in **Figure 2**.

Before measuring with mismatch, the characteristic impedance of the DUT shall be determined, e.g., with the "open/short" procedure according to Annex A of *IEC 62153-4-4*. The screening attenuation a_S is found with the arbitrary determined normalized value Z_S = 150 Ω:

$$a_S = 10 \times \log_{10}\left|\frac{P_1}{P_{r,max}}\right| = 10 \times \log_{10}\left|\frac{P_1}{P_{2,max}} \times \frac{2 \times Z_S}{R}\right| \qquad (2)$$

$$= Env\left\{-20 \times \log_{10}\left|S_{21}\right| + 10 \times \log_{10}\left|1 - r^2\right| + 10 \times \log_{10}\left|\frac{300\Omega}{Z_1}\right|\right\} \qquad (3)$$

where:

P_1	input power in Watt,
$P_{r,max}$	measured max. power in Watt,
a_S	Screening attenuation related to the radiating impedance of 150 Ω, in dB,
Env	minimum envelope curve of the measured values in dB,
r	reflexion coefficient $= \left\|\left(\frac{Z_0 - Z_1}{Z_0 + Z_1}\right)\right\|$ (4)
Z_0	is the system impedance resp. the output impedance of the generator, (usually 50 Ω),
Z_1	is the characteristic wave impedance of the cable under test, in Ω.

The term $10 \log_{10} |1 - r^2|$ represents the reflexion loss between generator and DUT due to the mismatch. A mismatch between a 50 Ω generator impedance and 75 Ω characteristic impedance of the DUT gives a correction value of approximately 0.17 dB.

Changes of IEC 62153-4-7, tube-in-tube procedure. The changes of *IEC 62153-4-3*, transfer impedance and *IEC 62153-4-4*, screening attenuation also appears in the revised part *62153-4-7*.

Under discussion here is the influence of measuring adapters, e.g., for the measurement of connectors and TV receiver leads. Measuring adapters shall be qualified before the actual measurement. Adapters will limit the sensitivity of the test setup.

For calibration, mated adapters are plugged together, connected to the tube in the tube system and measured with the same settings as during the test (see **Figure 4**).

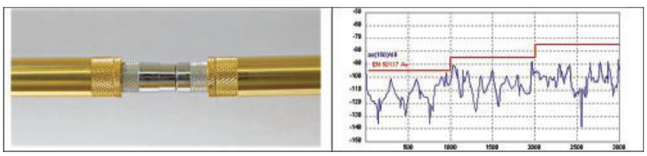

Fig. 4 — Test adapter.

When measuring assemblies with mated connectors (male and female), it may be easier to cut the cable, mount plug and socket together (treat it as a coaxial cable) and then measure according to *IEC 62153-4-7*. Thus, the influence of the measuring adapter is eliminated. In cases of doubt, this method is preferable to the method with adapters.

Improvements of Triaxial Test Procedure

The triaxial procedure was developed about 30 years ago as an alternative and extension to the absorbing clamping method in order to measure higher screening attenuation without screened room and to measure transfer impedance and screening attenuation with one test setup.

The requirement for the screening attenuation of CATV cables was 75 dB at that time. Meanwhile, it is important to measure coupling resistances of <1 mOhm/m and screening attenuation values of more than 120 dB. Thus, the requirements for the mechanical parts of the test setup increased considerably. All mechanical parts have to fit to the DUT and connect the DUT “RF tight” with the setup.

The mechanical components of the CoMeT system were constantly adapted to the higher requirements accordingly and new components were developed. Changes and improvements of the standards were taken into account accordingly.

For high shielding attenuation, a modified head sleeve is available (see **Figure 6**). The short circuit at the generator end can be realized by half shells with cone (see **Figure 7**). These cones are pressed to the screen with a clamping plate. Simultaneously twisting of the DUT is prevented by the clamp plate.

To measure screening attenuation in the ≥ 85 dB range, all mechanical parts have to fit to the screen to be tested. With adapted mechanical parts and with careful measurement set up, the measurement limit with a standard commercial network analyser is at < 50 μOhm or > 135 dB (see **Figure 5**).

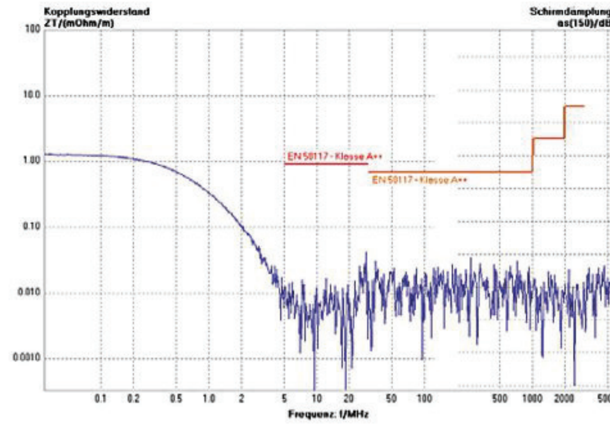

Fig. 5 — Maximum sensitivity of the CoMeT-system.

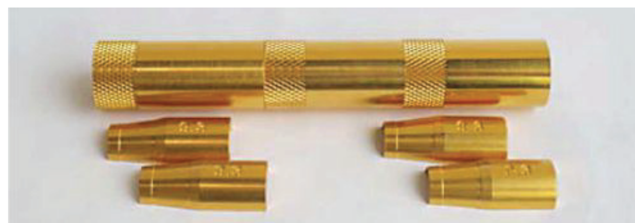

Fig. 6 — Improved sleeve for high screening.

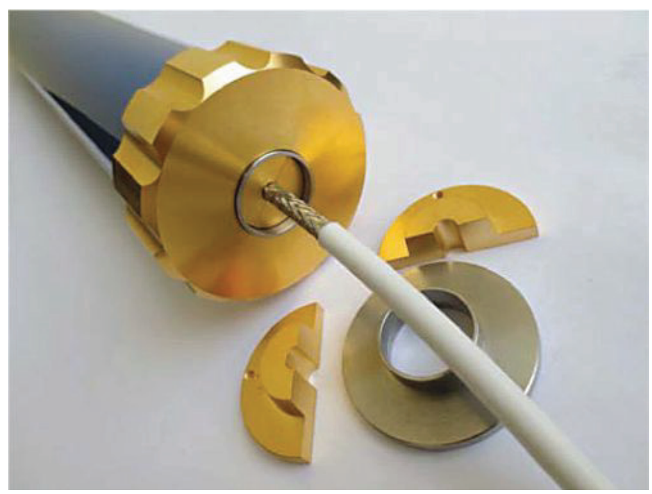

Fig. 7 — Modified short circuit with cone.

If in the standard version of the CoMeT system no matching parts are available, these may need to be adjusted for the respective measuring task or may be remade.

Sagging

When testing with the triaxial setup, the test specimen is to be installed centrally in the middle of the measuring tube. Sag of the cable in the tube results in changes of the characteristic impedance Z_2 of the outer system, and thus errors in the measurement result. The slack of the specimen can be avoided in different ways, for example by tensioning the test piece, by a vertical position of the measuring tube or by a foam insert with a suitable material having a low dielectric constant and good RF properties, for example Rohazell®.

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Cheap alternatives to Rohazell are for example, supporting discs made of styrofoam or insulating heating pipes. Investigations on insulating sleeves from hardware stores showed no significant effect on the measurement results.

Calibration/Verification Kit

Numerous users of the Triaxial procedure asked to be able to calibrate and verify the system.

The CoMeT-CalKit and the "tube in tube" system offers an easy possibility for calibration/verification of the triaxial setup to measure transfer impedance and screening attenuation according to *IEC 62153-4-7* (see **Figure 8**).

Fig. 8 — Calibration/Verification Kit.

From about 300 MHz to 3 GHz, the Calibration/Verification Kit provides a screening attenuation, which is in the range of screening class A of CATV cables per *IEC 61196*, *EN 50117* and of *IEC/EN 60966*. The Calibration/Verification Kit will be supplied with a calibration protocol (see **Figure 9**).

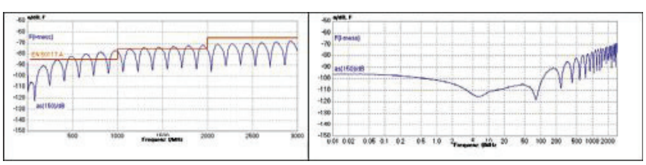

Fig. 9 — Curves of the calkit.

Long-Term Behavior

The shielding effect of different CATV cable was observed over a period of one week. The transfer impedance and the screening attenuation were measured from 10 kHz to 3 GHz with the triaxial setup. The cables were centered with a foam insert in the tube. Between measurements the test setup was completely at rest (see **Figure 10a** and **Figure 10b**).

After three to four days, a change of the screening attenuation of up to 8 dB was observed. This applies to both individual foil cable with CELL-PE insulation as well as cable with single braids with massive PE insulation (there was no change in the range of transfer impedance) (see **Figure 10c**).

If the cables, as required by the standards of the series *IEC 61196/EN 50117*, are pulled before the test through a pair of rollers according to *IEC 61196-1-314/EN-50289-3-9* (see **Figure 11**), this effect does not occur.

Conclusion

With the revised standards of the *IEC 62153-4-n* series, now measurements with mismatch between the generator and

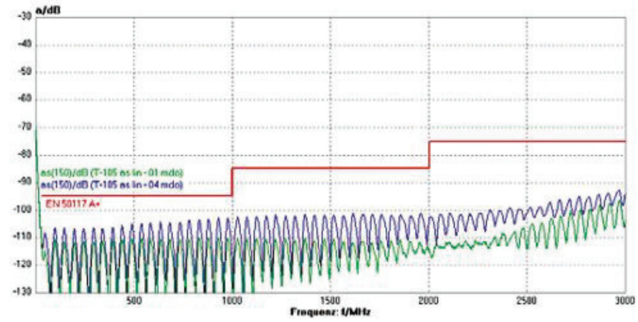

Fig. 10a — Screening attenuation direct and after four days storage.

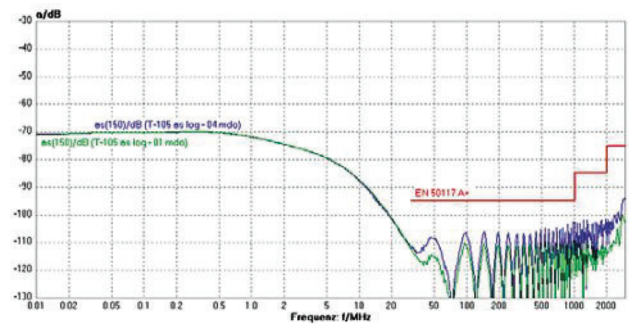

Fig. 10b — Coupling function direct and after four days storage.

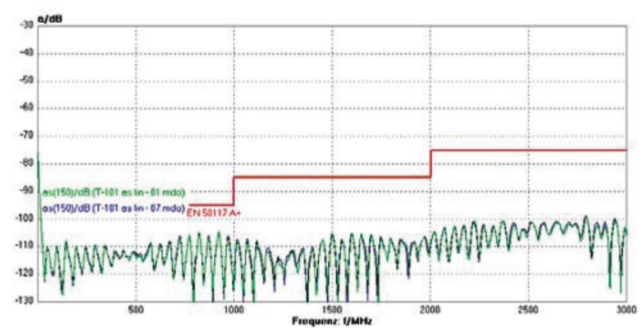

Fig. 10c — Screening attenuation after bending test direct and after four days storage.

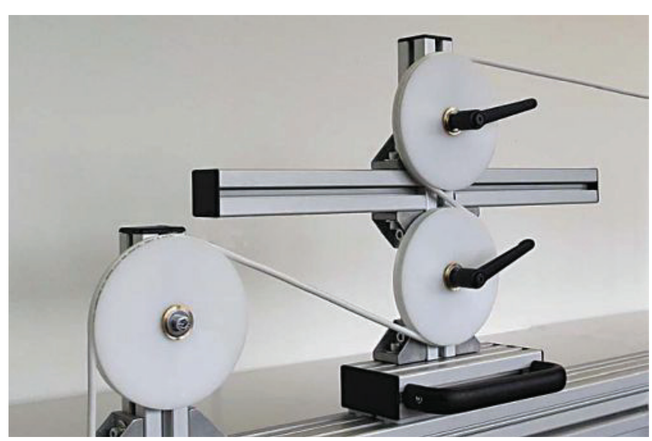

Fig. 11 — Bending device according to *IEC 61196* with respect to *IEC 61196-1-314*.

the DUT are possible. Impedance converters are no longer required. With the CoMeT Calkit, the calibration/verification of the triaxial test setup is possible.

Measurements of shielding effectiveness values of more than 130 dB up to and above 3 GHz can be achieved with the triaxial test setup without screened room. Round-robin tests with seven participants showed a repeatability of ±3 dB at 85 dB shielding effectiveness. However, measurements at screening attenuation ≥ 85 dB require special care during sample preparation and during the measurement as well as trained personnel.

Among others, the accuracy and the reproducibility of the shielding effectiveness of CATV cables depends on the test object itself. Cable designs of foils and braids are "unstable" structures, screening can be different along the cable and cables may change their screening during the time. Test samples should therefore be conditioned prior to measurement in accordance with the relevant standards (see **Figure 11**).

Further information is available by emailing the author at **bmund@bedea.com**. WCTI

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